小菜蛾之形性觀察及其天敵考查

吳　國　家

小菜蛾為世界性之十字花科蔬菜害蟲。而其為害十字花科蔬菜，往昔不如今日之嚴重，此或由於普遍、經常使用殺蟲劑防治後，小菜蛾似有獲得獨持之優良環境，而應用現代殺蟲劑防治，反得相反之效果。本報告為敍述小菜蛾各期蟲態之生活習性及天敵種類等等。此項區區資料或可藉以部份解釋小菜蛾所以特別猖獗之原因，供蔬菜害蟲防治上之參考。（本文承陶技正家駒、梁技正同庭指導與鼓勵，文成後並蒙陶技正賜正與吳技佐幹成代為繪製小菜蛾幼蟲小繭蜂及黃海燕小姐繪製小菜蛾生活史圖，特誌於此，藉表謝忱。）

一、小菜蛾之各期蟲態

卵　：小菜蛾之卵扁卵形，魚鱗狀。分佈於葉上，色白乃至檸檬黃色。表面有小而圓形之隆起部。孵化前由卵殼外面可透見其幼蟲之外形。卵長約0.44公厘，濶約0.26公厘。

幼蟲：小菜蛾之幼蟲長筒形，體毛較少，具有僞足5對。計齡期4齡，每次脫皮後，其頭濶與其體濶相等。但待幼蟲取食而進行生長後，體則變為紡綞形。第一齡幼蟲全體無色，頭暗褐色，頭顱淺色，但具暗褐色光澤。前胸背之中背線兩側有不規則之褐色斑紋。腹部中央部分最濶，而兩端漸形細小。腹部具剛毛，剛毛之基部環有淺褐色澤。而在足上亦有此種色澤之痕跡。以後各齡期幼蟲形與第一齡幼蟲相同，惟在放大鏡下觀察之，可辨有少許之不同。前胸背板斑紋變為許多褐色之斑點，成為剛毛之基部。環繞腹部剛毛四周之色澤區更為明顯，且較第一齡期更大而更深。最後一齡因其在胃內積集食物，故體常呈綠色。四齡幼蟲之頭顱闊及其體之長度為第一齡0.16×1.7公厘，第二齡0.25×3.5公厘，第三齡0.37×7.0公厘，第四齡 0.61×11.2 公厘。最後一齡至前蛹期則無脫皮現象，僅外形稍有不同，即前蛹之頭及胸部更為收縮，並呈淡綠色。

蛹　：小菜蛾之蛹前端圓形，胸部最濶，而向後端漸形細小。口器明顯。翅芽長達第五腹節末端。初化蛹時色灰綠，而逐漸變成淺棕色。蛹體有褐色斑紋，體長約7公厘。蛹體包被於兩端開口之精細網狀絲繭內。

成蟲：小菜蛾之成蟲為細小灰褐色之蛾。展翅約17.7公厘。休止時前翅置於體之兩側，接合於背上。後翅暗灰色。側面觀之，蟲體後端稍為上舉，一條乳黃色背紋由前至後，被其餘不規則黑色條紋區分為三部分不甚明顯之波狀紋區域，宛如鑽石之閃光，故小菜蛾名為 Diamond back moth。小菜蛾個體間雖有更明顯之色澤變化，但通常雌蟲色澤較雄蟲淺而斑紋亦欠明顯。

二、生活習性

生活習性觀察方法

（1）成蟲之飼養：自田間採集蛹體，置於玻璃瓶內，瓶口蒙蓋紗布，待其羽化後，將成對的雌雄蛾，放入口徑4公分，高10公分之玻璃瓶中，瓶內放入青梗白菜葉片供成蟲產卵之用。葉柄下端裹以溼潤棉花，以防止葉片急速乾燥。同時將各玻璃瓶分別編號，每日上下午各觀察一次，記錄其活動、交尾、產卵、壽命等情況。

（2）卵之飼（培）養：取成蟲產卵之葉片，分別記錄其卵數，產卵日期，時刻等。並逐日觀察卵粒之變化，注意其孵化之日期，時刻及孵化之歷時等項。

（3）幼蟲之飼養：用細毛筆筆尖將孵化之幼蟲小心的移至青梗白菜葉片上，每一葉片放飼一頭，然

後將葉片置於瓶中。所用之玻瓶與飼養成蟲者同。每日又將幼蟲用毛筆以同樣方法，移至新鮮葉片上，繼續飼養，並詳細觀察幼蟲之活動情形，取食習性及有無脫皮現象等事項。直至幼蟲老熟結繭化蛹，記錄蛹之歷期爲止。

小菜蛾之生活習性

（１）成蟲之習性：成蟲一般均在上午7—9時羽化，但亦有延至下午3—4時者。羽化後休息於飼養瓶內之菜葉上，飼養瓶上或紗布蓋上，若不受外界驚動，常靜止不動。成蟲在上午羽化後，則於下午、傍晚或晚間即行交尾，翌日黃昏或夜間開始產卵。日間及夜間均有交尾情事。交尾時間20分～２小時不等。成蟲一生交尾數次，交尾時靜止，交尾空間不需很大。羽化後，雌雄在口徑1.5公分，長９公分之玻璃管內，即能交尾、產卵。卵產於玻璃管上亦能孵化。成蟲產卵期通常是3～5天，惟短者僅１天，長者多達８天，平均3.6天。產卵數以第一天及第二天爲最多，佔總產卵數之80％，每一雌蟲產卵數頗不一致，據調查36頭雌成蟲產卵結果，最多者爲245枚，最少者爲18枚，平均121枚。成蟲趨光性很强，喜愛亮光。在室內飼養飛出時，則多飛往光亮之處。成蟲活動時間以傍晚至翌日清晨爲多，尤以晚間6～11時最爲活躍。成蟲雌雄比率據由幼蟲飼養至蛹羽化爲成蟲，三次考查485頭結果，雌雄之比率爲250：235，雌佔51.9％，略比雄蟲多些。成蟲壽命一般冬天較長，夏天較短。卵多產於葉片之主脈及支脈之處，葉背較葉面多些。有時亦產於葉柄上。在室內飼養時，亦有產於玻璃管上。卵爲散產，有時3～4粒相聚一處。

卵：剛產下之卵色白，稍帶黃色，後漸變黃色，而孵化前1～5時，即變爲褐色，最後變爲黑色。卵期2～7天、3～4天爲最多，平均3.9天，在定溫室內（23°c）爲４天。孵化率據四次考查306粒結果，孵化之卵279粒，佔91.2％。

（２）幼蟲之習性：幼蟲孵化時間自20分至３小時不等，平均２小時，孵化時刻多在白天，自上午七時至下午五時均有孵化現象。初孵化之幼蟲在原處停留約15～40分鐘後，乃開始爬動，尋找食物，並行吐絲。卵產於葉面上，孵化之幼蟲多數遷移至葉背適當處，侵入葉內，潛食葉肉，留下表皮，形成白色透明之食痕，此爲小菜蛾初齡幼蟲爲害之唯一特徵。初齡幼蟲食量微小，但如蟲數多時，被害葉片亦易察見。第二齡幼蟲有時亦潛食葉肉，但待三、四齡幼蟲則在葉片上下穿孔，取食爲害。幼蟲密集時，食完葉肉而留下葉脈，嚴重時亦食害葉柄。在花椰菜上能食害花蕾。幼蟲受驚時，有吐絲、假死、下垂習性。幼蟲性頗活潑，一旦受驚擾則迅速後退。如寄主不足取食時，常吐絲藉風力遷移或爬行遷移尋找食物。幼蟲一生脫皮三次，共計四齡。脫皮多在晝間進行。脫皮前靜止，並吐絲固定蟲體，進行脫皮。脫皮後靜止30分鐘至２小時不等，然後開始爬動，進行取食。食量隨齡期而增大，據調查40頭幼蟲之食量，爲第一天食1.14平方公厘，第二天食3.16平方公厘，第三天食8.06平方公厘，第四天食22.50平方公厘，第五天食68.00平方公厘，第六天食134.55平方公厘，第七天食37.68平方公厘，第八天食0.33平方公厘。幼蟲一生共食葉面積爲275.40平方公厘。老熟幼蟲在化蛹前３～５小時，即不進食，乃尋找適當處所化蛹。在飼養瓶內時，爬至蓋口紗布上、瓶壁上、葉片近葉脈或葉脈稍凹下處化蛹。化蛹前吐絲纏繞，作成紡錘形薄繭，幼蟲旋即化蛹其中，所脫之皮就近留於蛹體之末端。初化之蛹體呈綠色，後漸變淡綠色、黃綠色，最後變爲黃色。蛹體如受外界干擾，仍能活動。蛹爲自由蛹，自絲網外面可透見之。蛹期３～12日，平均6.3日。

生活年史：小菜蛾一年之中發生情形及出現代數，經54年（1965）６月開始飼養觀察，至55年（1966）７月爲止，又分室內及室外（網室內）同時進行。據觀察結果，一年間室內發生19代（圖二），室外發生18代（圖三）。其每一代期間之長短，受氣溫之影響很大。室內完成一代爲13～34天，平均16.8～20.6天，室外爲13～37天，平均17.2～21.6天，在定溫室內（23°C）則爲17～20天，平均18天。

小菜蛾田間發生密度，隨季節而異，據54年（1965）2月至5月調查甘藍20株之卵、幼蟲、蛹在植株上葉背及葉面分佈情形，如圖四所示。即在同一株上之卵、幼蟲及蛹之棲息密度，因月日而異。不論卵、幼蟲或蛹，均以葉背居多，因之，如行藥劑防治，葉之兩面必須完全噴到方可。

三、天　　敵

小菜蛾之天敵，以膜翅目寄生性姬蜂、小繭蜂、小蜂、卵蜂、雙翅目之寄生蠅爲主。據已知記錄已達23屬63種之多，並已行國際間交換及大量繁殖放飼，成爲生物防治別開生面之一環，而最成功之著例爲新西蘭。

臺灣小菜蛾之寄生性天敵，在臺北本所應用動物系園地內，發現兩種，即蛹寄生蜂，爲蛹姬蜂 *Diadromus* sp. *，可能爲 *D. collaruis* Gravenhort，但有重複寄生蜂發生，該蜂亦屬姬蜂，爲 *Itoplectis naranyae* Ashmead.*。

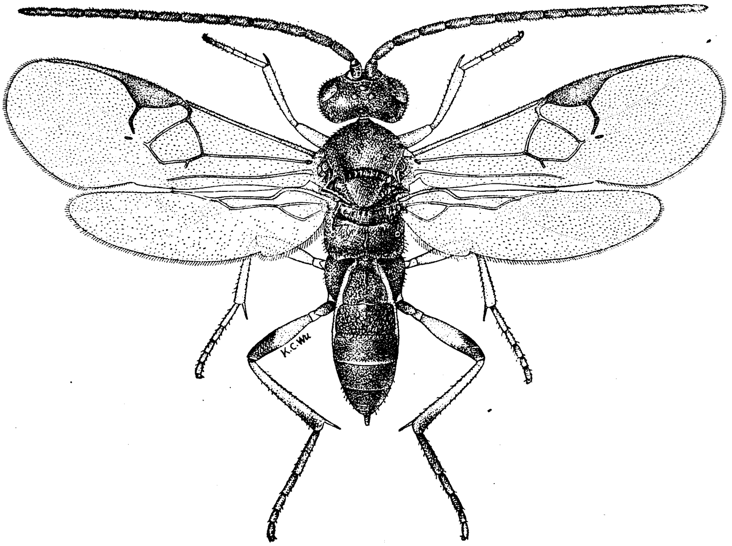
小菜蛾蛹寄生蜂在未施任何殺蟲劑之甘藍上，55年（1966）3月中旬採集162頭蛹，經室內飼育考查結果，寄生者63頭，達40%。

次爲小菜蛾幼蟲小繭蜂 *Apanteles plutellae* Kurdjumov.** 該蜂分佈於歐洲之烏克蘭、意大利、法國、荷蘭、非洲之摩落哥、利比亞、亞洲之印度、日本及臺灣，而臺灣爲新記錄。

小菜蛾幼蟲小繭蜂（圖一），成蟲雌雄體色均黑色。前中足之轉節、轉基節、腿節、脛節及跗節均黑色。前中足之基節、後足轉基節腿節、脛節、脛節距、肩板、腹節基部皆紅褐色。翅痣暗色。

頭之顏面全部及額區密佈點刻。顏面之凹陷部較接近上唇基片。後單眼與複眼分明。雌蟲觸角鞭節較頭、胸、腹之和爲長，但較頭、胸、腹之和長之2倍爲短。雄蟲觸角約爲頭、胸、腹和之3倍等長或短些，或爲胸部之3倍之長。

胸部沿中胸背板縱溝下行成一狹縱線及一大區域，該區至少佔據中胸背板之後半部。前緣及側緣有皺摺點刻，其他區域有光澤及點刻。後緣光滑、小楯板刻溝新月形，小楯板盤有皺摺點刻，或爲深



圖一　小菜蛾幼蟲小繭蜂 *Apanteles plutellae* Kurdjumov 雌

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點刻。中縱區稍爲凹下，偶有一明顯之中縱隆起。翅之徑脉之第一横線與横肘脉等長，基脉上部短，後緣紋與翅痣等長。後足基節有皺紋，後足脛節距等長，約爲其後足跗節之基節之 $\frac{1}{2}$ 長。

腹部第一腹背板基部爲深凹陷，中央十分膨大，有時有短中縱隆起，先端向上捲起，在膨大之基部略平滑，其他地方有皺摺點刻。第二腹背板有皺紋，第三腹背板平滑。以後各腹背板有細點刻。腹部腹板無中縱線。產卵管鞘較基節尤短，約爲第二、三腹節之和之長。產卵管較基節長，但較後足跗節之基節及第二節之和之長爲短。

小菜蛾幼蟲小繭蜂寄生率據55年（1966）2、3月間在本所未曾使用任何殺蟲劑之甘藍上採集三、四齡幼蟲，携回室內飼養，先後五次計164頭，其結果寄生者43頭，寄生率達 37.5 %。此蜂喜產卵於小菜蛾第二、三齡幼蟲，據考查10頭寄生蜂結果，小菜蛾幼蟲被其產卵後，經 7 ～10天，小繭蜂幼蟲老熟，鑽出寄主體外，結一白色小繭，化蛹其內。蛹經 6 ～ 8 天羽化，完成一代需13～18天，成蟲壽命 7 ～22天，被寄生之小菜蛾幼蟲自小繭蜂幼蟲老熟鑽出結繭後，始告死亡。一寄主幼蟲僅有一頭小繭蜂幼蟲寄生，故爲單獨寄生。而小菜蛾黃色小繭蜂 *Apanteles* sp. 因發現不多，暫略述之。

小菜蛾近年來為害嚴重性之探討

臺灣之小菜蛾由於冬季溫暖如春，照常發育爲害，故一年之中出現代數頗多，計室外18代，室內19代。因發生代數多，故對於外界不利於其生活上之物理、化學因子，可在短時間內產生抗性因子，形成抗性小種，代代相傳，以致無法用一種或同類衍化物之殺蟲劑來防治。最初如 D.D.T. B.H.C.後來又如 Malathion, Parathion Diazinon 等，先後均相繼失效。

又據考查不使用任何殺蟲劑之甘藍上，小菜蛾幼蟲及蛹被小繭蜂及姬蜂兩種寄生蜂寄生達77.5%（37.5%及40%）換言之，在未普遍應用殺蟲劑防治蔬菜害蟲以前，小菜蛾之密度平時已被此兩種寄生蜂控制高達 7 成或 7 成以上，無怪小菜蛾當時不爲主要之害蟲。固然，此項膚淺之觀察，不足以斷言小菜蛾在目前爲害嚴重之理由，但亦可解釋一二，作爲今後改進十字花科蔬菜害蟲防治技術上之參考。

應用殺蟲劑防治蔬菜害蟲，保持蔬菜固有之產量和品質，是無可諱言的，決不可以爲小菜蛾之因爲對任何一種殺蟲劑，因一年中繁殖代數多，容易產生抗性小種，和犧牲有效天敵寄生蜂等等而不使用殺蟲劑，以致影響其他害蟲之爲害，仍不能達到栽培蔬菜之目的。故應在防治小菜蛾其他方法上去尋求，如應用微生物來防治小菜蛾，以彌補其缺點。此種防治方法國外已有報告，再據本所陶技正家駒56年（1967）在越南西貢田間試驗結果，亦獲同樣效果，似可改變防治小菜蛾方策，以濟燃眉之急。

結　　　論

臺灣十字花科蔬菜害蟲——小菜蛾，由於冬季溫暖，一年繁殖代數頗多，故對於殺蟲劑受自然淘汰法則，極易產生抗性小種，經常使用一種或類同之衍化物，失却防治效果。不但如此，平時控制七成以上之小菜蛾有效天敵之幼蟲小繭蜂及蛹姬蜂，在目前應用之各種殺蟲劑防治蔬菜害蟲情形下，無法立足，以平衡小菜蛾密度。因之，在此雙重作用下造成今日防治十字花科蔬菜害蟲上之難題。爲今後防治小菜蛾計，似可由藥劑防治以外之其他方法中去尋求。

参 考 文 獻

以下所列爲小菜蛾生活習性，天敵有關之文獻，至藥劑防治則概未錄入。因迄目前尚無一種殺蟲劑可以持續而有效地防治小菜蛾幼蟲。

Ankersmit (G. W.) 1953 DDT-Resistance in *Plutella maculipennis* (Curtis) (Lep.) in Java, Bull. ent. Res. 44, 421-425.

Atwal (A.S.) 1955 Influence of temperature, photoperiod and food on the speed of development, longivity, fecundity and other qualities of the diamond-back moth *Plutella maculipennis* (Curtis) (Lepidoptera: Tineidae) Aust. J. Zool. 3, 185-221.

Beck (S. D,) 1965 Resistance of plants to insects, Annual Review of Entomology 10, 207

Blanchard (E. E.) 1947 Descriptions and notes on Argentine Microgasterines, Arthropoda 1, 6-22.

Bonder (G.) 1928 *Plutella maculipennis*, a serious pest of cabbage in Bahia, Chacaras e. Quintaes 28, 602.

Brethes (J.) 1923 The cabbage moth, *Plutella maculipennis*, Curt. An. Soc. Rural Argentina, 57, 162-166.

Cherian (M. G.) & Basheer (M.) 1939 *Brachymeria excarinata*, Gahan (Fam. Chalcididae) a pupal parasite of *Plutella maculipennis*, Curtis in South India, Proc. Indian Acad. Sci. 7 (B) 6. 289-299.

Delucchi (V.), Tadic (M.) & Bogavac (M.) 1954 L'elevage en masse de *Apanteles plutellae* Kurdji. (Hym., Braconidae) et de *Angitia tibialis* Grav. (Hym., Ichneumonidae), parasites endophages de *Plutella maculipennis*, Curt., et notes biologiques sur ces parasites, Plant Prot, 21, 20-41

De Silva (M. D.) 1961 Microbial control, 1. Laboratory tests on the susceptibility of the Lepidopterous pests of cabbage in Ceylon to commercially prepared *Bacillus thurigiensis* Berliner, Trop. Agriculturist 116, 273-286.

Dosse (G.) 1959 A hitherto unknown type of damage by *Plutella maculipennis* Curt. on winter rape and mustard, with supplements on the morphology of the larvae, Z. Pflkrankh. 66, 150-156.

Edwards (W.H.) 1930 A destructive pest of cruciferous crops, The small green cabbage worm, *Plutella maculipennis* Curt., J. Jamaica Agric. Soc. 34, 582-583.

Fischer (E.) 1929 Is a new outbreak of the cabbage moth, *Plutella maculipennis*, to be expected in 1929?, Die kranke Pflanze 6 66-68.

French (R. A.) & White (J. H.) 1960 The diamond-back moth outbreak of 1958, Plant Path. 9, 77-84.

Frost (S. W.) 1949 The diamond back moth in Pennsylvania, J. econ. Ent. 42, 681-682.

Fox (C. J. S.) & Jaques (R. P.) 1961 Field tests with *Bacillus thurigensis* Berliner and DDT for control of two pests of cabbage, Canad. J. Pl. Sci. 41 428-430.

Girault (A. A.) 1922 New Chalcid-flies from Eastern Australia, 3, Hymenoptera, Insector Inseitiae Menstrus, 10, 148-154.

Given (B. B.) 1944 Notes on the physical ecology of *Diadromus (Thraiilla) collaria* Grav. N. Z. J. Sci. Tech. 26 (A.), 198-201.

__________ The relative food-consumption of diamond back moth and white butterfly larvae, N. Z. J Sci. Tech. 26(A)195-197.

__________ Longevity of diamond back moth (*Plutella maculipennis*-) adults in relation to nutrition, N. Z. J. Sci. Tech. 26, 192-194.

Gray (R. A. M.) 1915 The prevention of egg-laying on turnips by the diamond back moth, J. Bd. Agric. London, 22. 222-226.

——————— 1931 The diamond back moth *Plutella maculipennis* during the years 1914-1929, J. r. Hort. Soc., 56, 48-55.

Gupta (P. D.) & Thorsteinson (A. J.) 1960 Food plant relationships of the diamond back moth (*Plutella maculipennis*, Curt.) 1. Gustation and olfaction in relation to bontanical specificity of larva, Ent. exp. appl 3, 241-250.

——————— 2. Sensory regulation of oviposition of the adult female, Ibid. 305-314.

Gunn (D.) 1917 The small cabbage moth (*Plutella maculipennis*, Curt.), Union S. African Dept. Agric., Pretoria Bull 8, 10 pp.

Gurney (W. E.) 1924 To control cabbage moth, Agric. Gaz. N. S. W. 35, 325.

Harcourt (D. C.) 1958 Biology of the diamond back moth, *Plutella maculipennis* (Curt.) (Lepidoptera: Plutellidae), in eastern Ontario, 1. Distribution, economic history, synonyms and general descriptions, 37th Rep. Quebec Soc. Prot. P1. 1955 155-160.

——————— 2. Life-history, behaviour and host relationships, Canad. Ent. 89, 554-564.

——————— Distribution of the immature stages of the diamond back moth, *Plutella maculipennis* (Curtis) (Lepidoptera: Plutellidae), Canad, Ent. 92, 517-521.

——————— 1961 Design of a sampling plan for studies on the population dynamics of the diamond back moth, *Plutella maculipennis* (Curtis) (Lepidoptera: Plutellidae), Cand. Ent. 93, 820-831.

Hardy (J. E.) 1938 *Plutella maculipennis*, Curt., its natural and biological control in England, Bull. ent. Res. 29, 343-372.

Harper Cray (R. A.) 1915 The prevention of diamond back moth outbreaks, Jl. North of England Hortic. Soc., nos. 53, 54, 197-201.

Hassanein (M. H.) 1958 Biological studies on the diamond back moth, *Plutella maculipennis* Curtis (Lepidoptera: Plutellidae), Bull. Soc. ent. Egypte 42 325-337.

Helson (C. A. H.) 1960 *Bacillus thuringiensis* Berl. as a potential means of control of cabbage white butterfly (Pieris rapae L.), diamond back moth (*Plutella maculipennis*), and some other Lepidoptera, N. Z. J. agric Res. 3, 1009-1014.

Hulsenberg (H.) 1929 Observations on the occurrence of *Plutella maculipennis*, Curt., in the Erfurt Cauliflower District in 1928, Die kranke Pflanze, 6, 88-91.

Kanervo (V.) 1933 The diamond back moth, a serious vegetable pest, Puutarha 35, 71-74.

——————— 1936 The diamond back moth as a pest of cruciferous plants in Finland, Valt. Maatalousk. Julk, 86, 86 pp.

Kanervo (V.) 1947 Sporadic observations concerning diseases in certain species of insects, 3. Diseases attacking *Plutella maculipennis* Curt., Ann. ent. fenn. 12, 143-153.

Khristova (E) 1957 *Plutella maculipennis*, Curt. and its control, Nauchni Trud. Minist. Zemedel. 1, 239-255.

Kopvillem (Kh. C.) 1960 Material for the study of parasites of the cabbage cutworm and the cabbage moth in the Moscow region, Rev. Ent. USSR 39, 806-818.

List (C. M.) 1937 Possible migration of diamond back moth, J. econ. Ent. 30, 676.

Lloyd (D. C.) 1949 Host selection by Hymenopterous parasites of the moth *Plutella maculipennis*, Curtis, Proc. roy. Soc. Ent. (B.) 128-853, 451-484.

Lloyd (D. C.) 1942 Further experiments on host selection by Hymenopterous parasites of the moth, *Plutella maculipennis* Curtis, Rev. canad. Biol. 1, 633-645.

Lucien Bonnemaison 1965 Insect pests of crucifers and their control, Annual Review of Entomology 10, 233.

Marsh (H. O.) 1917 Life-history of *Plutella maculipennis* (Diamond-back moth). Jl. Agric. Research 1, 1-10.

Meier (N. F.) 1925 A few words on the biology of *Angitia fenestralis*, Holmgr., and on immunity in insects, Defense des plantes, 2, 147-150.

__________ 1926 The biology of *Angitia fenestralis*, the parasites of *Plutella maculipennis*, and some notes on immunity in insects, Zeitschr. angrew. Ent. 12, 139-152.

Milles (H. W.) 1924 The diamond back moth, *Plutella maculipennis*, Curt. Ann. Rep. Kirton. Agric. Inst. 1923, 45-48.

Miner (F. D.) 1947 Life history of the diamond back moth, J. econ. Ent. 40, 581-5_3.

Morgan (W. L.) 1929 Preliminary experiments in cabbage moth control, Agric. Gaz. N. S. W. 40, 781-766.

__________ 1931 Experiments in cabbage moth (*Plutella maculipennis*) control, 1930, morgcm(W.L.) Agric. Gaz. N. S. W. 42, 57-58.

Muesebeck (C. F. W.) 1922 A revision of the North American Ichneumon-flies belonging to the Subfamilies Neoneurinae and Microgasterinae, Proc. U. S. Nat, Mus. 61, no. 2436, PP. 1-76.

Muggeridge (J.) 1930 The diamond back moth, its occurrence and control in New Zealand, N. Z. J. Agric. 41, 253-264.

Wuggeridge (J.) 1939 Parasitic control of Pests, experiments with white butterfly and diamond back moth, N. Z. J. Agric. 58, 305-307.

Nayar (J. K.) & Thorsteinson (A. J.) 1963 Further investigations into the chemical basis of insect-host Plant relationships in an oligophagous insects, *Plutella maculipennis* (Curtis) (Lepidop-tera: Plutellidae), Canad. J. Zool. 41, 923-929.

Oka (I.N.) 1957 Laboratory experiments on the control of *Plutella maculipennis* with *Bacillus thruiginiensis* Berl., Tehnik pertanian 6, 113-134.

Otanes (F. Q.) & Sison (P.) 1927 Notes on the diamond back moth, *Plutella maculipennis* Curtis, Philip. Agric. Rev 22, 251-254.

Pimental (D.) 1961 Natural control of caterpillar population on cole crops, J. eocn. Ent. 54, 889-892.

Prasad (S. K.) 1963 Quantitative estimation of damage to crucifers caused by cabbage worm, cabbage looper, diamond back moth and cabbage aphid, Indian J. Ent. 25, 242-259.

Predtetohenski (S.) 1925 The cabbage moth, *Plutella maculipennis*, Curtis. Astrakhan Sta. Plant Prot., Leaflet 55, 23 pp.

Reichardt (A. N.) 1921 *Plutella maculipennis*, Curt., Bull. Sub-section control plant pests attacked to the Petrograd Committee of rural economy 1, 6-77.

Robertson (P. L.) 1939 Diamond back moth investigation in New Zealand, N. Z. J. Sci. Tech. (A.) 20, 330-364.

____________ 1948 *Eupteromalus* sp. as a hyperparasite, some indication of its influence on the establishment of *Angitia cerophaga* in New Zealand, N. Z. J. Sci. Tech 29 (B)5, 257-265.

Roman (A.) 1918 Contributions on the Swedish Ichneumonidae Pentagoni, ArKiv for Zoologi, 12, 2, 1-32.

Shaw (M. W.) 1959 The diamond back moth *Plutella maculipennis* (Curtis) a historical review with special reference to its occurrence in Scotland in 1958, Trans. R. Highl. agric. Soc. 6, 4, 56-80.

____________ 1962 The diamond back moth migration of 1958, Weather 17, 221-234.

Shteinberg (D. M.) 1961 Host-parasite relations in entomophagous insects, The possibility of the development of larvae of certain parasites. Hymenoptera in hosts new for them, Dokl. Akad. Nauk SSSR 138, 1477-1480.

Simmonds (F. J.) & Perron (J. P.) 1960 Record of *Plutella maculipennis* Curt. and some of its parasites in Kashmir, India, Canad Ent. 92, 278.

Stuart (A. M.) 1957 *Ephialtes brevivornis* (Grav.) as an external parasites of the diamond-back moth, *Plutella maculipennis* (Curtis) Bull Ent. Res. 48, 477-488.

Swezey (O. H.) 1915 A preliminary list of the Hymenopterous parasites of Lepidoptera on Hawaii, Proc. Hawaiian Entom. Soc., 3, 99-109.

Tanada (Y.) 1956 Microbial control of some Lepidopterous pests of crucifers, J. Econ. Ent. 49, 320-329.

Taylor (G. G.) 1948 Experiments for control of white butterfly (*Pieris rapae* L.)and diamond back moth (*Plutella maculipennis* Curt.) on cabbage. N. Z. J. Sci. Tech. 29 (A) 265-272.

Telenga (N. A.) 1931 Hyienopterous Parasites of the Fam. Ichneumcnidae, reared at the Kuban Plant protection Station in 1927, Plant Protection 6, 225-226.

Temep (W.) 1928 Work against the cabbage moth, Die kranke Pflanze, 8, 121-122.

Thorsteinson (A. J.) 1953 The chemotactic responses that determine host specificity in an oligophagous insect, *Plutella maculipennis* Curt. (Lepidoptera), Canad. J. Zool. 31, 52-72.

____________ 1955 The experimental study of the chemotactic basis of host specificity in phytophagous insects, Candd. Ent. 87, 49-57.

Timberlake (P. H.) 1918 Notes on some of the immigrant parasitic Hymenoptera of the Hawaiian Islands, Proc. Hawaiian Entom. Soc. for the year 1917 3, 399-404.

Todd (D.H.) 1957 Incidence and parasitism of insect pests of cruciferous crops in Hawke's Bay, Wairarpa and Manawatu, 1955-56, N. Z.J. sci. Tech.38, 720-727.

____________ 1958 Incidence and parasitism of insect pests of cruciferous crops in Hawke's Bay, Wairarapa., Manawatu, Rangitikei and Taranaki, 1956-57, N. Z. J, Agric. Res. 1, 847-858.

Torka (V.) 1929 Parasites of the cabbage moth, *Plutella maculipennis* Anz. Schadlingsk. 5, 3, pp. 39.

Tzedeller (O. E.) 1931 The cabbage moth, *plutella maculipennis* Curt. in connection with the cultivation of mustard, Zh. opuitn. Agron. Yu-vostoka 9, 2, 165-195.

Ullyett (G. C.) 1943 Some aspects of parasitism in field populations of *Plutella maculipennis* Curt., J. ent. Soc. sthn. Afr. 6, pp. 65-80

________________ & Schonken (D. B.) 1940 A fungus disease of *Plutella maculipennis* Curt. in South Africa with notes on the use of entomogenous fungi in insect control, Sci. Bull. Sep. Agric. For. S. Afr. 218, 24 pp,

________________ 1943 The control of the small cabbage moth, Fmg. in s. Afr. 1943 repr. 112.

________________ 1946 New species of *Apanteles* (Hym: Bracon.) and new host records from South Africa, J. ent soc. sthh. Afr. 9, 28-35.

________________ 1947 Mortality factors in populations of *Plutella maculipennis* Curtis (Tineidae: Lep.) and their relation to the probelm of control, Ent. Mem. Dep. Agric. S. Agric. 2, p6. 6, 77-202

vvan Emden (F. I.) : 1942 A Tachinid parasitic on *Plutella maculipennis* Curtis., Bull. Ent. Res. 33, 223-225.

Venkatraman (T. V.) 1964 Experimental studies in superparasitism and *Hymenobosmina rapi* (Cam.), the larval parasites of *Plutella maculipennis* (Curt,') Indian J. Ent. 26, 1-32.

Vos (H. C. C. A. A.) 1953 Introduction in Indonesia of *Angitia cerophaga* Grav., a parasite of *Plutella maculipennis* Curt., Contr. gen. agric. Res. Sta. 134, 32 pp.

Voukassovitch (P.) 1927 Observations biologiques sur les parasites de *Plutella maculipennis* Curtis (Lepidoptera: Plutellidae), Rev. Path. veg. Ent. agric. 14, 113-118.

Watanabe (C) 1939 A new species of *Apanteles* bred from Daimio tethys Menetries with notes on other species, Insecta Matsumurana 13, 129-131.

Wilkinson (D. S.) 1939 On two species of *Apanteles* (Hym. Bracon.) not preciously recognised from the Western Palaearctic Region, Bull. ent. Res. 30, 77-84.

BIONOMIC STUDY OF *PLUTELLA MACULIPENIS* CURTIS

Kou-Chai Wu

SUMMARY

Observation method:

The total number of observation was 20. The studied material was taken the pupae from field and caged in bottle which covered with cheese cloth. After emerging, picked up the copulating couple and induced into 4 X 10 cm vial provided a complete leaf of green petiole variety of Chinese cabbage and near the leaf base was surrounded with moistened cotton for egg laying and maintenance leaf fresh. The number of eggs, duration of adult life were recorded in the morning and afternoon twice a day respectively.

Picked up and put the egg laid leaf into clean vial for recording egg stage. The hatched larva was picked up separately with wetted Chinese pen and put into clean vial which had

provided with fresh, clean leaf for feeding. Number of moults, larval stage, pupation, emerging, pupal stage, preoviposition, oviposition, died and adult stage were recorded.

Observation results:

1. Adult: Based on 485 adult record, the female ratio was 51.9%. The adult emerged usually from 7 to 9 AM until 3 to PM. Male and female took copulation usually in evening and laid eggs in next evening. The copulation period lasted from 20 minutes to 2 hours. The adult activity started from 6 to 11 PM. Egg laying period took 3–5 days, the shortest was one day and the longest 8 days respectively. Number of eggs laid by one female based on 36 female record was 18–245 and 121 in average.

2. Egg: Egg was laid on the main or branched vein and sometimes on the petiole of leaf, single or 3 to 4 eggs serially arranged more on the underside than on the upperside of leaf. The egg color was white in first then changing to yellow and brown just before 1 to 5 hours of hatching. Egg stage was 2–7 days and usually 3–4 days. Percentage of hatching based on 306 egg record was 91%.

3. Larva: There were 4 larval stages, The body length of lst instar was 0.8–1.5 mm., anal legs unforked; 2nd instar 1.5–3.5 mm., anal legs forked; 3rd instar 3.5–6.0 mm, broaded along middle and narrowed at both ends; 4th instar 8.5 mm., The totel larval stage was 6–19 days and 9.6 days in average. In constant temperature of 23°C. was 9–10 days and 4, 2, 2, 2, days of lst, 2nd, 3rd and 4th stadium respectively. The larva usuallv hatched from 7 AM to 5 PM, it took 1 1/3–3 hours and 2 hours in average for completing hatching process. 15 to 40 minutes after hatching, it began to search food and spin silk. If the egg was laid on the upper side of leaf, it usually moved to the underside and mined into leaf tissue as the leaf miner and left the cleared leaf epidermis. The 2nd instar sometimes was still mining in the leaf tissue but most of them fed outside, 3rd and 4th instar fed outside of leaf and made holes, in severe infestation, the feeding hole usually connected each other and just left leaf veins, the petiole was also infested. The larva when was being disturbed usually spinning silk and moved backward. When moulting it span silk and wove to fix its body. If lack of food, it span silk to be spreaded by wind or migrated by walking for searching food. The consumption of food was very few in lst and 2nd instadium, but in lst and 2nd day old of 4 instadium consumed lots of leaf, based on 40 larva record was 275.40 mm. square of leaf in average for full larval stage.

The mortality of larva was low, about 5%. There were 2 species of Braconids *Apanteles plutellae* Kurdj. and *A.* sp. which parasited in 3rd to 4th instar. The percentage of parasitism was 37.5% in without chemical control field. The braconid laid eggs in the 2nd and 3rd instar larva of *Plutella*, its egg including larval stage took 7–10 days, after maturation, it came out from the host larva and span coccon beside its host for pupation, its pupal stage took 6–8 days, from egg laying to adult emerging took 15.3 days in average.

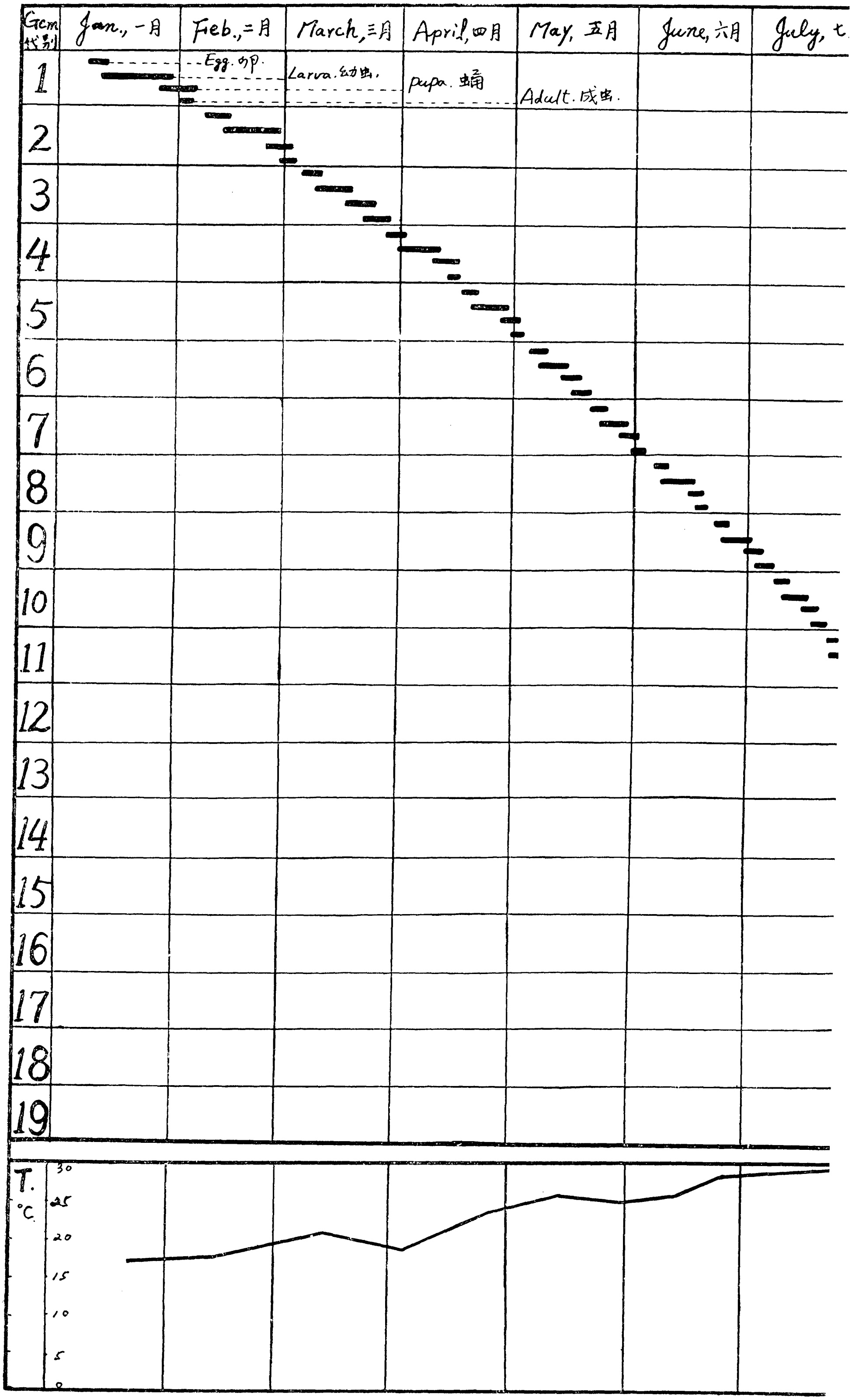
4. Puap: Before 3–5 hours of matured larva stopped feeding, span silk to weave spindle loose cocoon along veins in concave place of underside of leaf for pupation. The larval skin was discharded at the end of pupa within the cocoon. The pupa color was initially green then turning yellowish green, yellow. The pupal stage took place 3–12 days, in constant temperature 23°C. was 4–5 days. The mortality of pupa was .very low, but it was

usually parasited by a species of Ichneumonid, *Diadromus* sp. (probably *D. collaris* Gravenhorst). The percentage of puapl parasitism in without chemical control field was 34 to 44%

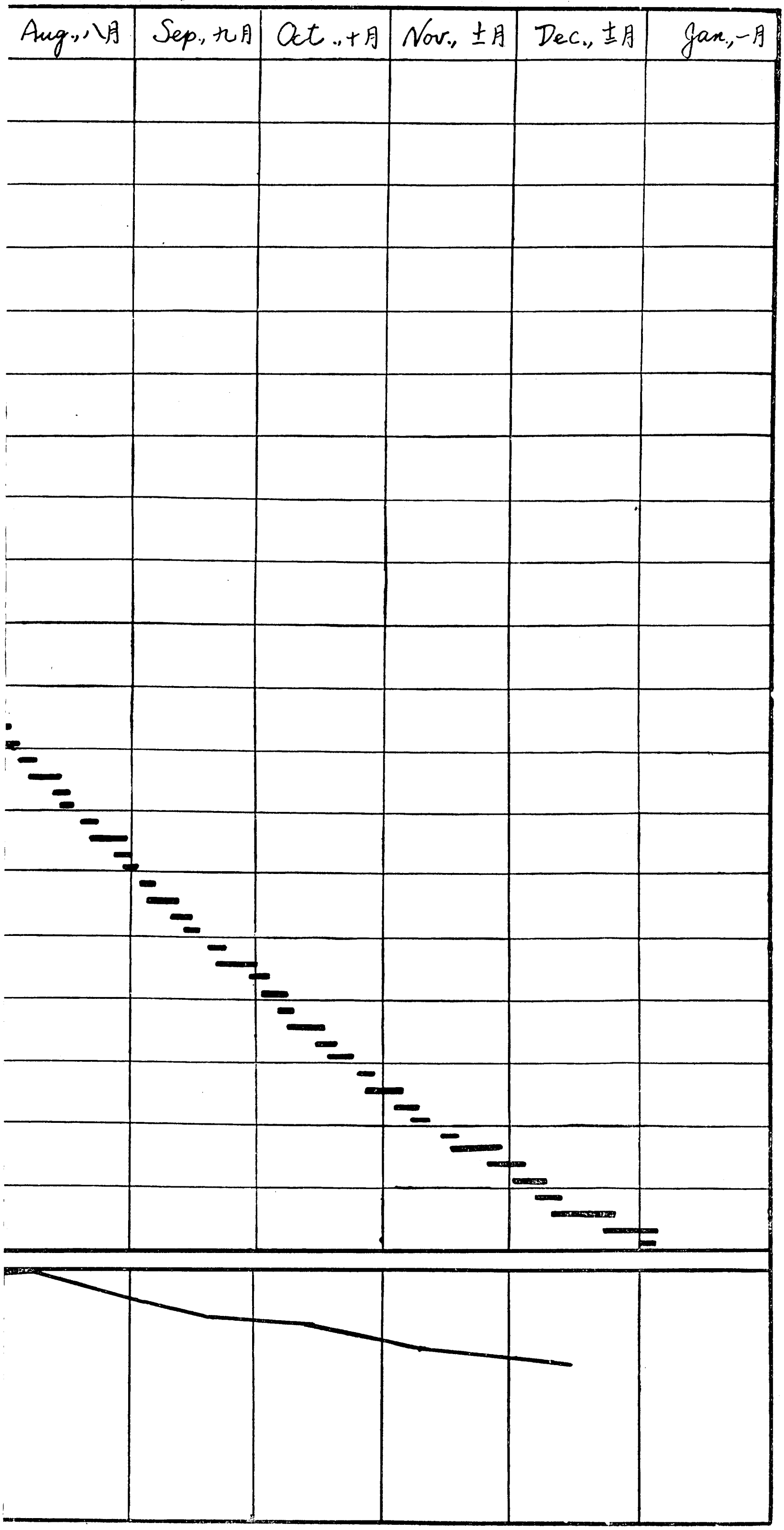
5. Annual generations: This observation was made form June, 1965 to July, 1966. It hac 19 generations in room temperature and 18 generations in outside of room annually. Tc complete one generation was 13-34 days in room and 13-37 days in field and 17-20 days ir constant temperature of 23°D. respectively

6. The outbreak of dimond back moth on this island since the extensive use of new development insecticides like DDT, BHC, malathion, parathion, diazinon etc which were easily to build up the resistant strain due to the quick development and could not establisl its effective larval and pupal parasites to check the diamond back moth in uneconomic level For overcoming this difficulty, it seems to have to change the control method beside insecticides.

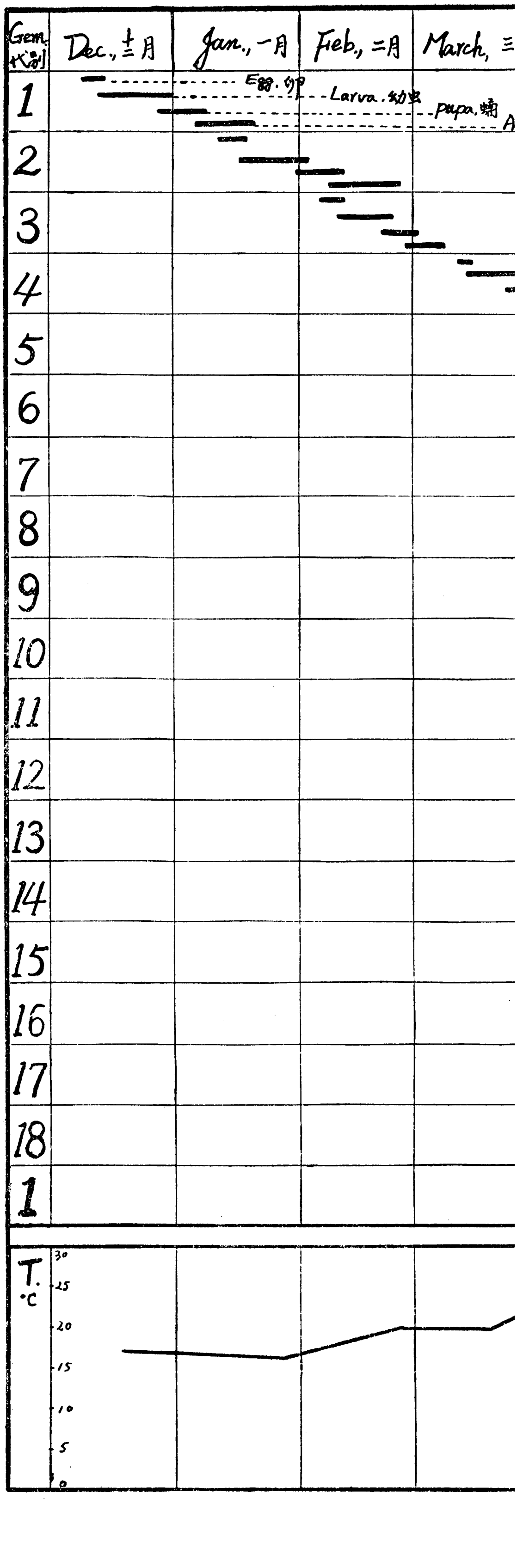
圖二 Fig. 1. Seasonal Appearance of Diamond Back Moth in Room



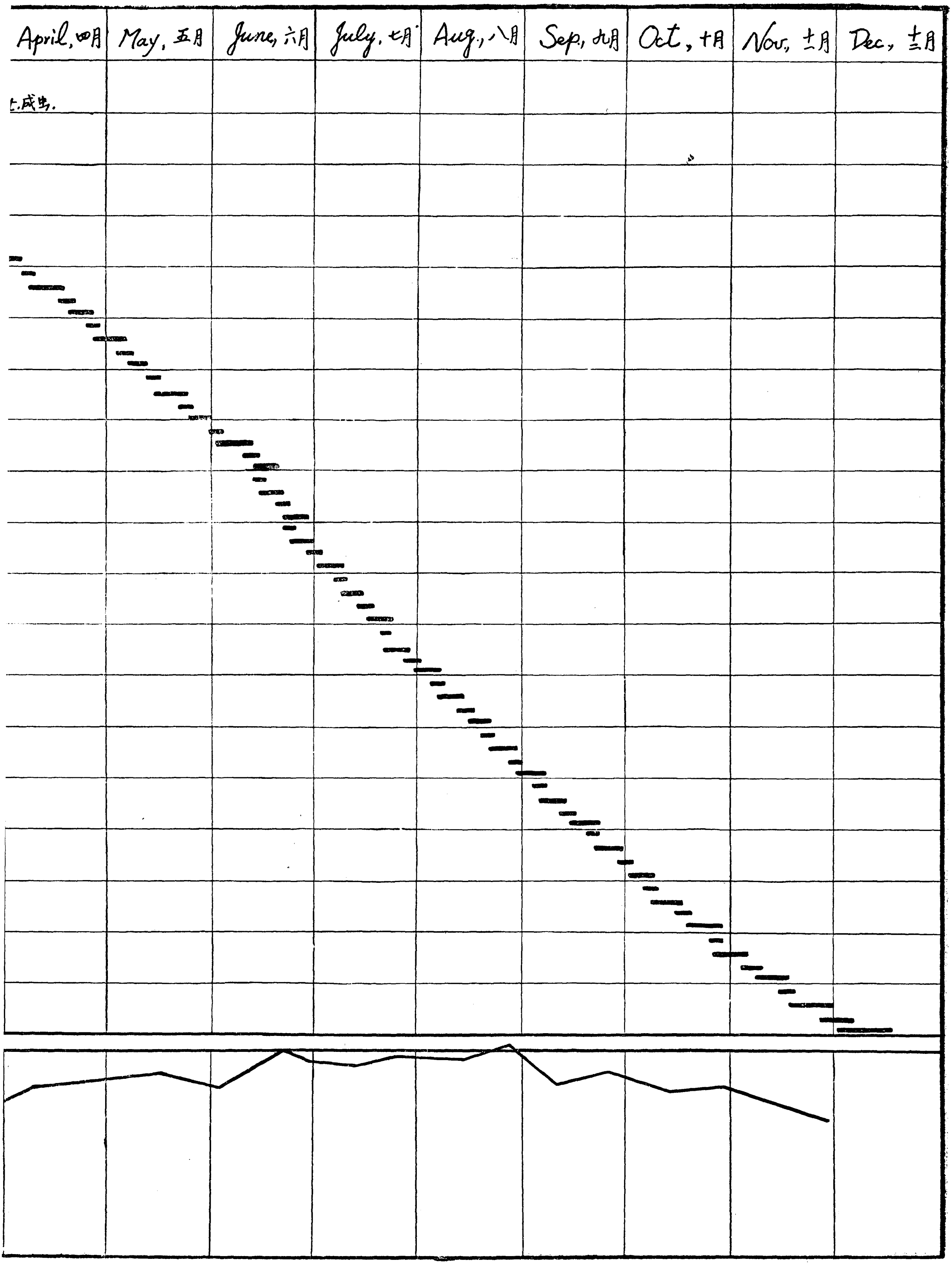
'emperature (June, 1965—July, 1966) 小菜蛾室內生活年史



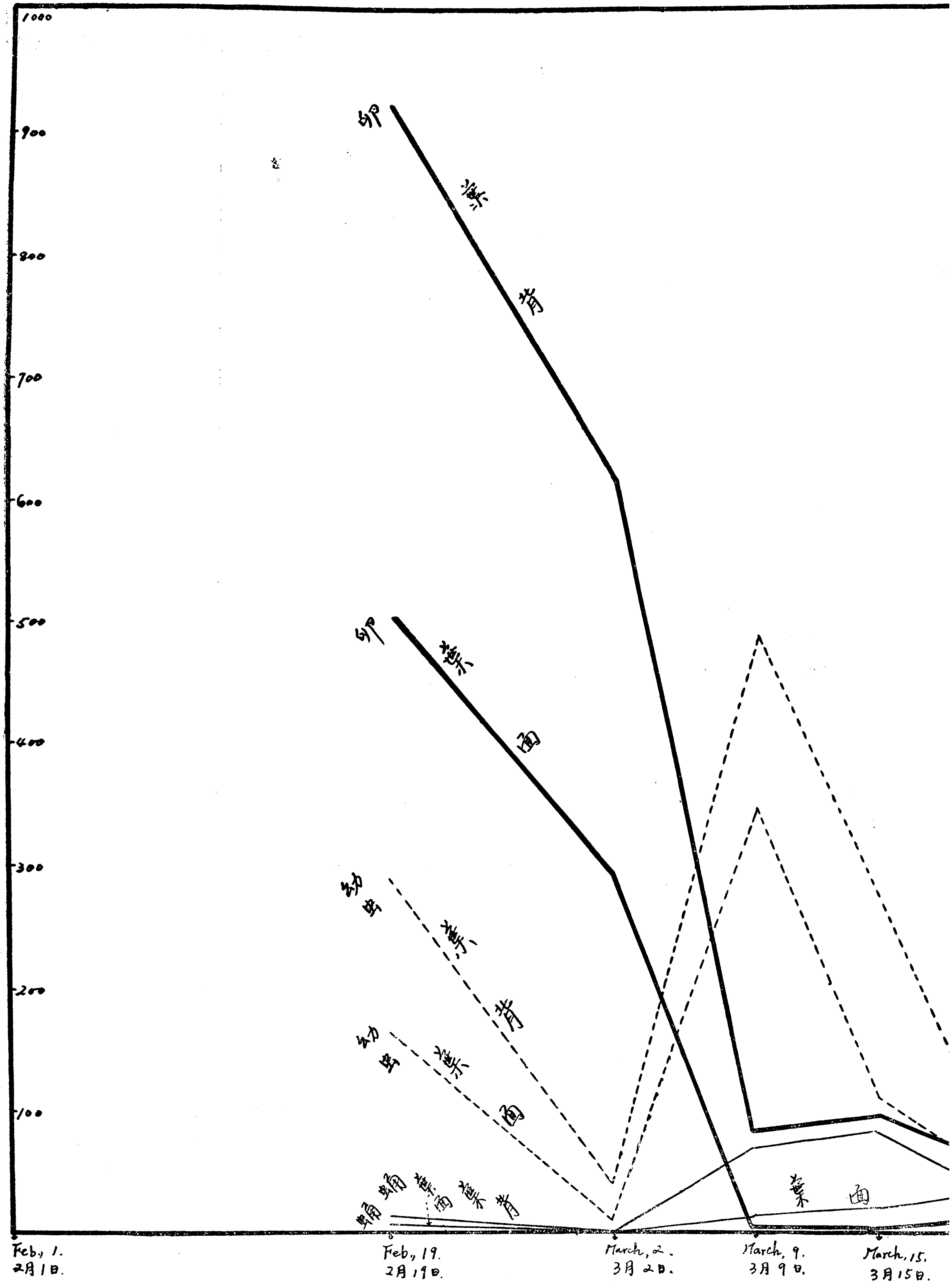
圖三 Fig. 2. Seasonal Appearance o

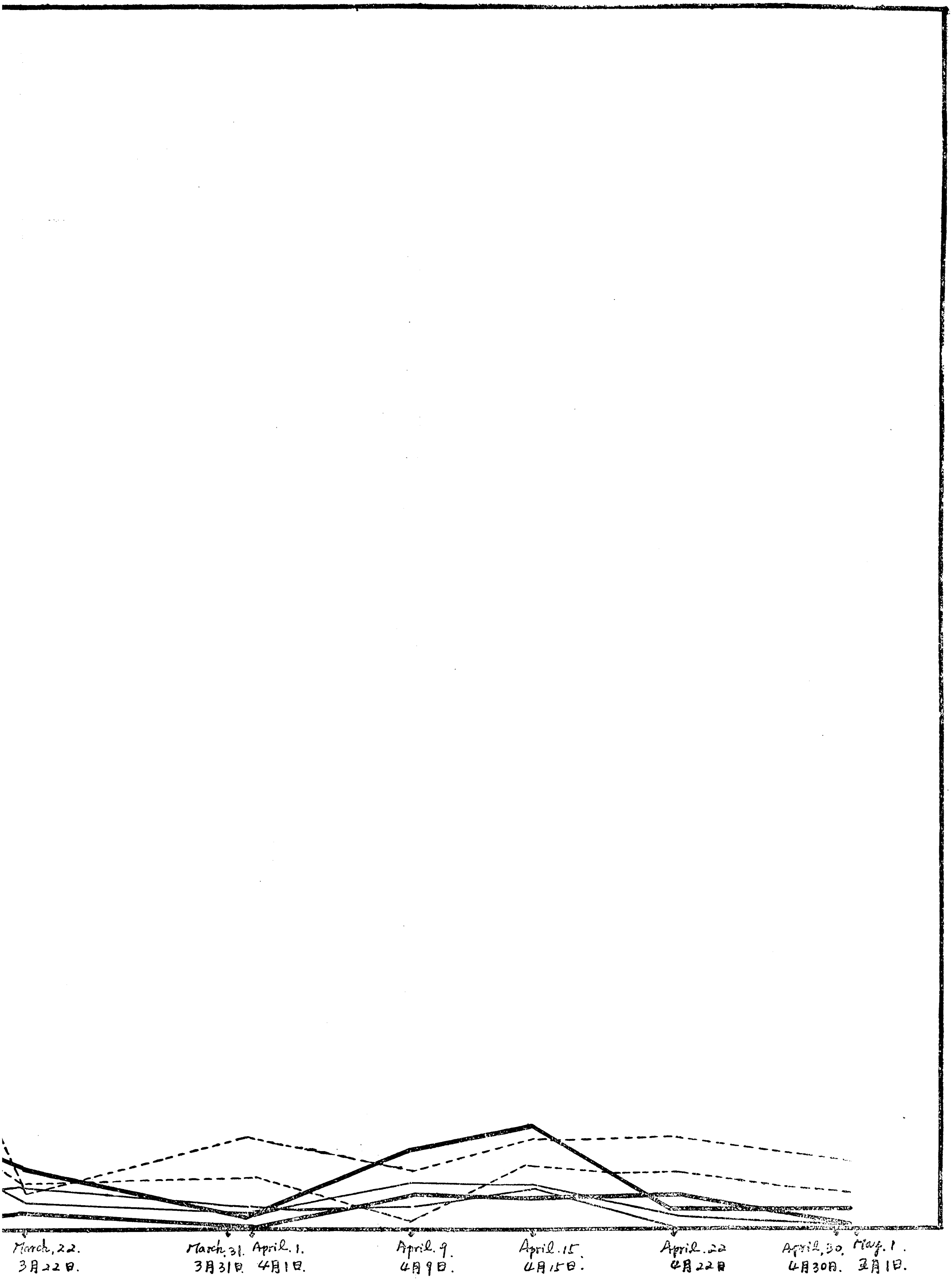


Diamond Back Moth in Field Cage Temperature (June, 1965—July, 1966) 小菜蛾室外生活年史



圖四　Fig. 3. Field Population Survey of Diam




March, 22. 3月22日.
March. 31. 3月31日.
April. 1. 4月1日.
April. 9. 4月9日.
April. 15. 4月15日.
April. 22. 4月22日
April, 30. 4月30日.
May. 1. 5月1日.